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Fire Management Notes

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An international quarterly periodical devoted to forest fire management

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Contents

Cover: Fire hose being shipped at Boise Interagency Fire Center during hectic 1985 fire season. See article begining on p. 6.

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Send suggestions and articles to Chief, Forest Service (Attn: Fire Management Notes), P.O. Box 2417, U.S. Department of Agriculture, Washington, DC 20013.

Training Fire Sleuths of the Forest

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It has long been an axiom of mine that the little things are infinitely the most important.

—Sherlock Holmes

You know my methods. Apply them.

—Sherlock Holmes

When most of us think of wildfire, we don't immediately associate it with crime. But most human-caused wildfires are crimes, felonies or misdemeanors, and, like other crimes, require careful investigation to determine their cause and origin. Most of us probably don't envision ourselves as detectives like the wise Sherlock Holmes or the quick-witted Kojak. After a quick check of the fire scene, we're more apt to record our best estimate of the wildfire cause based on readily available evidence, if there is any, and move on to the next fire or return to more pressing duties demanding our attention. "Police work" is someone else's job. But that attitude is changing. More and more it's becoming our job, too.

Arson, for example, is no longer just a local or regional problem—it's a national one—and with the increase in arson crimes comes the demand for better fire cause investigation to determine who started the fires, why, and how. Better investigation enhances our ability to identify our human-caused wildfire problems and solve them.

One obvious way to improve investigative skills is through training. There are a number of wildfire cause investigation training courses around. We'd like to highlight one such course, hoping that it might in some way serve as a model for others interested in improving their investigative skills.

In June 1985, the Michigan Interagency Wildfire Prevention Group (MIWPG), a cooperative organization consisting of Federal, State, and private agencies responsible in varying capacities for wildfire prevention, sponsored a 5-day training course in wildfire cause investigation. The purpose of the course was to teach the participants the fundamentals and techniques of wildfire cause investigation and the prosecution process. The participants could then systematically determine the cause of wildfires and pursue their cases in court. They could also train their coworkers in the same techniques.

After hearing that the Minnesota Department of Natural Resources (DNR) has an outstanding team of instructors, the MIWPG invited them to teach a fire cause investigation course in Michigan. The five members of this team have extensive experience and training in law enforcement and arson investigation. They are also seasoned instructors capable of enthusiastically presenting interesting and relevant course material. To supplement the program, guest speakers were invited to discuss special topics. For example, a prosecuting attorney reviewed the legal process followed in civil, criminal, and juvenile cases. He discussed proper courtroom dress and demeanor and described the cooperation attorneys require of forest officers if they are to make good courtroom presentations. Another expert, a forensic specialist from the Michigan State Police crime lab, described procedures to use when collecting and handling evidence found at the scene of a crime.

To allow more one-to-one contact, the course was limited to 35 students who came from a number of different agencies—the Michigan DNR, Michigan State Police, USDA Forest Service, USDI Fish & Wildlife Service, and Michigan State Firemen's Association. Most of these students were either trained, professional law enforcement officers or forest managers responsible for fire cause investigation in their administrative units. Regardless of their background and experience, however, they were all attending the course to improve their skills and enhance their knowledge of wildfire cause investigation.

Whether it's the attention we pay to clues pointing to the origin of a fire or the procedures we follow to painstakingly document our observations, it is true that the little things are the most important (fig. 1). These activities and more are essential if we are to enhance our chances of successfully completing investigations and pursuing them in court. During

the training course, students learned the important details of good detective work. Classroom presentations, all recorded on videotape, included:

- A review of Michigan fire laws and principles of fire behavior.
- Clues to a fire's origin in burn patterns and fire direction indicators.
- Ignition devices used to start wildfires.
- Maintenance of case files and notebook records during an investigation.
- Procedures and techniques used when interviewing suspects and witnesses.
- The legal process used in civil and criminal cases.
- Profiles of habitual or purposeful fire setters.
- Photographs of evidence at the fire scene.
- Methods to determine if vehicle or structure arson started a wildfire.
- Collection and handling of evidence found at the fire scene.
- Procedures to safely stop and approach a vehicle to question the passengers.
- Surveillance planning, equipment, and techniques.
- Procedures to determine the cause and origin of wildfires.

Figure 1—*Can you find the matches that started this wildfire? Despite the fire's 5-acre size, a well-trained investigation team found these matches by carefully following clues to the fire's origin in burn patterns and fire direction indicators.*

Knowing that the "little things" are important in wildfire cause investigations, the students were given a chance to test their knowledge and hone their skills in a simulated wildfire situation.

Two field exercises, which were also videotaped, were conducted after the course work was completed. Before the first exercise, the Minnesota training team in conjunction with the Michigan DNR set six wildfires in a control area and extinguished them when they reached 1 to 5 acres in size. The students were divided into six teams. Each team was assigned a fire location and asked to find the fire's origin and determine its cause (fig. 2). After this exercise, each team described how it used burn patterns and fire direction indicators to locate the area of origin, which thus enabled the team to find the ignition device.

The second, more extensive exercise was designed to simulate the "real thing." Once again, six fires were set and extinguished and one

burn area assigned to each of the six teams. This time, however, members of each team had to go through the exercise just as they would in an actual wildland fire situation. Team members interviewed witnesses (role-played by volunteers) on or near the fire scene, prepared plaster casts of tire tracks and footprints, systematically searched the area for evidence, and photographed, collected, and preserved evidence. These activities were done in addition to all of the other activities essential to a good wildfire cause investigation. When the investigation was completed, a member from each team made a classroom presentation reporting what the team did and what it found during the course of the investigation.

One big factor contributing to the success of this exercise was the fire-cause investigation kit supplied to each team by the Michigan DNR. Housed in a specially designed, protective metal box, the kit contained more than 40 items necessary to conduct a thorough investigation of a wildfire.

After 5 days of intensive training, the course participants returned home equipped with the knowledge and skills to conduct wildfire cause investigations. Having this interagency cadre of trained investigators available, Michigan is one State well on its way to solving its wildfire problems.

Figure 2—*A fire investigation team carefully searches for the ignition device.*

It's up to us to learn the secrets that point to the cause and origin of wildfires if we are to make any headway in preventing them. Fire prevention planning is accomplished through information received from fire reports. The more accurate the information received, the better the prevention plan. Training in wildfire cause investigation is one way to improve this information and to become a Sherlock Holmes of the forest.

For further information about the course, the instructors, the investigation kits, or the videotapes, contact:

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BIFC in 1985...The Biggest and Busiest Year Ever

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The Boise Interagency Fire Center (BIFC), Boise, ID (fig. 1), turned 20 on April 1, 1985. However, no one took time to mark the occasion. Everyone was already too busy responding to a level of fire support requests unprecedented in BIFC's 20-year history. During one 10-day period in early July, the Fire Center moved more firefighters and other firefighting resources over a broader geographic area in a shorter time than ever before. By the end of the year, the Center had received reports of more than 83,000 wildfires and close to 3,000,000 acres burned across the United States.

Figure 1—*Boise Interagency Fire Center, Boise, ID.*

Weather's Impact

The stage was set for the 1985 fire season in December 1984. Much of the Eastern United States had well above normal temperatures, combined with precipitation shortfalls ranging from 25 percent in New England to 75–90 percent in southern Florida. The West suffered a dry and cold winter, with dry areas including southern California and sourthern Nevada, Utah, western Arizona, New Mexico, and Colorado. This trend of warm and dry weather in the East and cold and dry in the West continued through April. Most of the East and West Coast States were in severe to extreme drought by May. In June, extreme drought showed up in large areas of northern and southern California, northern Washington, central Idaho, and most of Montana. In Alaska, where the normal fire season peaks in May–July, conditions remained surprisingly wet and cool through late spring and early summer.

The Long, Hot Season

The 1985 fire season required record-setting interagency mobilization of personnel and equipment. The season really began in the Southeast in December 1984 with human-caused fires, aggravated by continuous drought, and continued with few breaks until late October 1985. Forest Service assistance to the States began in January when devastating fires prompted the Governor of Florida to declare a state of emergency. In April, fire activity in the Southeast declined for a while, but by mid-April there were major fires breaking out in Colorado and South Dakota, an unusually early time of the year for wildfire activity in those States.

In May, a new outbreak of major wildfire activity in the Southeast led to the commitment of six national fire overhead teams—the most ever to this area. These fires continued well into June, by which the extreme fire activity had spread into California, Oregon, and the Great Basin States of the West. During the height of the fire season, from mid-June through August, a record number of major fires burned in the West. In August, Alaska, which had been so cool and wet in the spring and early summer,

Figure 2—*BIFC mobilized 50,000 personnel during the unusually hectic 1985 fire season.*

suddenly broke into a large number of massive, lightning-caused wildfires in the interior. Nevada flared up again in mid-August, along with Oregon, Idaho, and Washington, in a series of major wildfires that continued though mid-September. Southern California, Oregon, and Washington rounded the season off with a flurry of severe fire activity well into October.

Major Forest Service fires included California's Wheeler and Gorda-Rat Fires, which consumed 118,000 and 56,000 acres respectively, as well as the Las Pilitas Fire, which burned 75,000 acres of the Los Padres National Forest. In Idaho, the French Creek and Savage Creek Fires and the Long Tom Complex burned a total of 55,240 acres of National Forest Lands. Interior and State Lands in Alaska had a combined total of 373,000 acres of fires. Oregon and Idaho also suffered severe damage from range fire activity—Oregon with 299,147 acres and Idaho with 243,275, almost all of which occurred on the Boise BLM District in southwest Idaho. The State most severely damaged by range fires was Nevada, where more than 750,000 acres burned, leading to serious concerns over watersheds and the possibility of the spread of Sahara-like desert lands.

The Fire Center's Response

For the Boise Interagency Fire Center, the 1985 fire season was the most active one in its history. During an average fire season, BIFC'S logistic support staff handles 2,500 orders for fire support resources—firefighters, support personnel, aircraft, and equipment. In 1985 the Center processed more then 6,500 resource orders. They mobilized 50,000 personnel, in comparison with the 10,000 mobilized during a normal fire season (fig. 2).

The Aircraft Desk normally orders 4 or 5 large contract transport aircraft, 50 airtankers, 60 light helicopters, and 1 or 2 military aircraft annually. During the long, hot fire season just past, they ordered an additional 65 light and medium helicopters to augment the contract ships and 155 charter flights to augment the 2,000 hours flown by the contract large air transports. The Forest Service Modular Airborne Firefighting System (MAFFS), a large, portable retardant pumping unit, was installed in the assigned Air National Guard and Air Force Reserve aircraft and activated to augment the airtanker system. The military was also contacted for 23 large transport aircraft to carry personnel and cargo. For the first time in 1985, the BLM contracted for a 727

jet large air transport. The 727 QC or "quick change" aircraft could quickly be converted from passengers to cargo and back again or fly a combination of the two. It flew 564 hours—282,000 miles, or the equivalent of 94 times across the continental United States. It carried 16,000 firefighters and 178,000 pounds of cargo at a considerable cost savings to the Federal Government.

In a normal year, the Forest Service Aviation Operations Staff inspects 40 airtankers, 5 large air transports, and 50 light helicopters to ensure they meet Forest Service operating and safety standards. This year they inspected an additional 35 light and medium helicopters along with numerous other aircraft to meet emergency mobilization needs. The Forest Service National Infrared Unit installed new, more sophisticated infrared detection equipment in its aircraft just in time for the 1985 season. The unit's two aircraft flew 545 hours worth of detection and mapping flights over 171 fires, often covering as many as three Forest Service regions during one evening's flight.

Innovations

There were many innovations by Fire Center Staff to meet mobilization needs. Not all were dramatic on the surface, but all had major impact on supporting the firefighting forces and protecting natural resources. In one example, the Forest Service modified all catering, shower, and transport contracts to provide for a net 5-day pay provision because of the extreme cash flow problems encountered by contractors trying to meet unprecedented demands for services. In one instance, a caterer invoiced the government for $627,000, with another invoice for $648,000 about to be submitted. The contracting unit obtained quick turnaround time on payment for catering services. Another caterer's payment check for $376,000 was lost in the mail, and a second invoice for another $319,000 had been submitted. Contracting arranged to wire him the second check, located the lost one, and had a check issued in record time. Normal time for reissuing lost checks is 2 months.

BLM's National Radio Support Cache got into the satellite communications business on the French Creek and Savage Creek Fires in Idaho with the help of the Army's Special Forces. They set up earth station-computer interfaces in fire camp and at the dispatch office in McCall, ID. Using this hookup, they were able to transmit both voice and high-speed data between remote fire locations and town. This led to far faster and more accurate ordering of fire resources and concomitant savings in suppression costs. Both the Forest Service and BLM radio caches supported a combined total of 133 fires with a total of 18,000 radios, antenna systems, and supporting equipment and personnel.

In the process of meeting record demands for resources, the Manpower Desk mobilized 192 twenty-person crews from the Eastern United States and 41 crews from Alaska. During 1985, nearly every one of the 50 States was either part of the problem or part of the solution. In the area of supplies, BIFC's Fire Warehouse moved 2.5 million pounds worth $12.6 million to fires (fig. 3). Ineoming shipments were close to 3.9 million pounds and worth $9.5 million. Returns to the warehouse from firefighting agencies so far total $4.5 million. Meanwhile, the Equipment Maintenance Seetion was using its new Pulaski rehandling machine to rehandle 16,000 Pulaskis and shovels, which were then resharpened and otherwise refurbished and returned to the field for further use.

More than 9,300 firefighters were based at the Fire Center itself. They were housed at the National Guard Barracks at Gowen Field, fed (26,700 meals), and transported to and from the fires. The Transportation Section alone drove 242,000 miles with its buses and trucks over narrow and hazardous mountain roads, carrying firefighters and supplies to and from fire camps.

Summary

If all of this seems to be a litany of numbers, BIFC is in the logistics business. The Center acts as a broker of fire resources—finding where they're available and getting them to where they're needed in the most expedient and cost-effective fashion

Figure 3—*The BIFC fire warehouse moved 2.5 million pounds of supplies in 1985.*

possible. The participating players at BIFC are BLM, the Forest Service, the National Park Service, the Bureau of Indian Affairs, the Fish and Wildlife Service, and the National Weather Service. The Fire Center's area of service includes all of those agencies, the 50 States and, when requested, 7 Canadian Provinces as well. The 1985 situation required a massive interagency mobilization of resources at all levels. Before the season was over, BIFC had responded to requests for assistance in 18 States and 2 Canadian Provinces. At one point in early July, there were more than 17,000 firefighters on the line and major fire activity in 11 States: California, Oregon, Arizona, New Mexico, Colorado, Nevada, Idaho, Montana, Utah, Nebraska, and South Dakota.

The logistical efforts of BIFC were augmented by those of the States, counties and localities, the military, especially the National Guard, and the General Services Administration. A large number of able and dedicated personnel from Federal and State agencies came to Boise to work long hours in assisting BIFC to complete a task that would have been impossible to accomplish without their help. The fire season of 1985 will be the season against which mobilization efforts of the future will be measured for many years. ■

NFMAS Slide/Tape Available

The USDA Forest Service Cooperative Fire Protection staff, in cooperation with Colorado State University, has developed a new slide/tape presentation entitled "A Fire Management Analysis System for State Foresters." This slide/tape discusses the problems facing past and present wildland fire managers; provides an overview of the National Fire Management Analysis System (NFMAS) fire simulating model; and presents four case studies of the system's application.

The NFMAS model compares the economic efficiency of alternative fire management organizations and funding levels. It displays fire effects and their economic implications.

The slide/tape is not intended to train people to use the model, but rather to introduce the subject to fire planners and those associated with fire management, such as budget personnel and policy makers.

A copy of the tape may be obtained from the nearest USDA Forest Service region or area office with cooperative fire responsibilities or from the USDA Forest Service, Cooperative Fire Protection Staff, P.O. Box 2417, Washington, DC 20013. ■

A Video Image Analysis System for Measuring Fire Behavior[1]

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Procedures used to measure or estimate fire behavior often require investigators to assemble and integrate data from a panorama of highly variable fire processes. In order to establish quantitative relationships between fire behavior and fire effects, numerous measurements are needed. This process can be expensive, time consuming, and fraught with error when subjective observations and manual methods of analysis are used. Objective observations coupled with automatic analysis can overcome these limitations as well as provide new opportunities to better understand wildland fire processes.

In this paper, we describe a low-cost video image analysis system now being developed at the Southern Forest Fire Laboratory. An overview of the instrumentation and methods and a summary of a current application are presented. Although image analysis technology is widely used in other fields, we believe this is the first quantitative application in the field of wildland fire science.

Background

For both wildland manager and fire researcher, the required accuracy for estimating fire behavior varies. In fire control, one can visually recognize when a fire's intensity has reached serious proportions. Guidelines for fire control have been published that evaluate labor, equipment, and safety considerations for different levels of fireline intensity as determined by visual estimates of flame length (*2, 9*). Sometimes, subjective expressions such as cool, hot, low, medium, or high are used by investigators to describe a fire's intensity. Much the same subjectivity can be found in the expressions of prescribed fire practitioners. The terms "winter burn," "summer burn," "low intensity," or "high intensity" are often used in prescribed fire research publications to describe the fire treatment. Although qualitative expressions may be adequate in some instances, there are occasions where both high accuracy and precision are needed to properly evaluate fire effects and to establish quantitative relationships that can be used in fire models.

For example, relating fire behavior to fire effects requires measuring the variability of the fire's intensity and not just fire "averages." Two sites may be treated with fires yielding identical average values for fireline intensity. Yet, one site may have significant scorch and losses because a higher percentage of the site may have been subjected to damaging values of fire intensity.

Although some instrumental methods are available to directly measure fire behavior parameters, they are both expensive and labor intensive and thus rarely used. Consequently, most fire-intensity data have been derived indirectly from published relationships of intensity to fire spread, flame length, and crown scorch (*3, 4, 10*). Of these methods, visual estimate of flame length has been widely recommended in technical reports (*6, 7*). Unfortunately, the accuracy of the visual method is poor, and the procedures not well established. In addition, there is considerable confusion about the difference between flame height and flame length.

Rigorous continuous monitoring of fire behavior has been accomplished by scaling images from individual frames of motion picture film for flame characteristics (*1, 5*). Photo methods are useful, but they have limitations. Operational costs of photo methods (cost of film development, etc.) are high and followup analysis methods can be very labor intensive. Video methods, on the other hand, offer most of the advantages of photo methods without some of the disadvantages. Video methods offer real-time assessment of image quality, low operational costs, and high portability. Furthermore, video images are easy to retrieve and are readily adaptable to computerized analysis methods.

The availability of economical video equipment and low-cost microcomputer systems prompted our efforts to develop an integrated system for fire documentation and analysis.

[1]The authors wish to acknowledge the technical assistance provided by John Harbin, electronics technician, and Robert Burgess, physical science technician.

System Description

The system has two distinct subsystems: (1) The image acquisition subsystem that creates and records the image replica, and (2) the data analysis subsystem that digitizes, stores, and analyzes the data.

Image acquisition subsystem. This subsystem includes a video camera with integral timer, recorder, portable monitor (optional), and camera targets or reference points. Our initial work was accomplished with a consumer grade RCA VHS format video camera (RCA Model CCO15) and portable recorder (RCA Model VJP900). This separate camera and recorder unit was used for about one year but proved too bulky (total weight 6.7 kg) for some of the field applications.

At present, we are evaluating the performance of a more easily portable, integral camera/recorder unit (JVC Model GR–C1U). This unit, which weighs 1.9 kg, is capable of recording up to 20 minutes of video on a VHS–C cassette. The VHS–C cassettes can be adapted to standard VHS cassettes. Camera battery packs are either 30- or 45-minute capacity, depending on the model selected. Data can be viewed onsite on a real-time basis by use of the camera viewfinder or an optional portable color monitor. Figure 1 shows the separate RCA camera-recorder and the all-in-one JVC "cam-corder" system. An additional benefit provided by these systems is the opportunity to simultaneously record a time-correlated voice-log on the cassette audio track.

Image analysis subsystem. The analysis subsystem allows the user to examine images that have been stored on the VHS recording media and extract geometric information from the images. For fire behavior purposes, this information could be flame length, height, angle, or relative position. With the assistance of computer algorithms, other parameters may be described. By using information on a frame-to-frame basis, time-dependent parameters such as rate of spread can be computed. Most of these parameters are derived from x, y, z coordinate data from image features. The analysis subsystem is divided into three functions:

- Image playback.
- Digitization.
- System software.

Image playback. The recreated image used for computer analysis is produced by a high-quality VHS recorder/player. A primary requirement of this component is that it reproduce the playback video with as much precision in timing as possible to reduce image jitter during video and graphics mixing. Our initial work

Figure 1—*Video systems; separate camera and recorder on the left and combined camera/recorder unit on the right.*

was accomplished with a low-cost ($400) consumer grade recorder (RCA Model VJP900). This system was adequate for recording fire behavior but inadequate when used in the still-frame mode. We are now using a studio-quality editing recorder (JVC BR8600) that cost $2,600. This recorder has proved successful and facilitates higher speed image retrieval.

Digitization. Images may be digitized by means of a cursor or pointer whose vertical and horizontal movement is calibrated to register directly in real units. Video images can be viewed as a mosaic of small picture elements (pixels) that are arranged in rows and columns. To establish a point-to-point measurement, a cursor is positioned at one of these picture elements by means of a graphics pointer (mouse). The computer establishes and records the position based on x and y coordinates. The cursor is then moved to the next position and the steps repeated.

This information can be processed by the computer for measures of length, width, area, angle, and three-dimensional graphic reconstruction. In our system, digitizing is accomplished by electronically overlaying the graphics workspace of a desktop computer (AT&T PC6300) onto a playback image displayed on a color monitor. A graphics pointing device (mouse) is used for operator cursor control, allowing the operator to select features or contours on the image to be digitized. The image analysis subsystem components are shown in figure 2 integrated into a mobile work station.

Systems software. Control, calibration, and data saving functions are provided through a control program written in IBM (Microsoft) BASIC and 8086 assembler language. Digitized data may be written to a standard MS/DOS diskette providing data interchange capability with any IBM–PC compatible computer. By providing raw digitized data to a computer algorithm designed to specification, other useful information may be provided about the geometric character of the fire under investigation.

The following is a summary of system components and costs (development work is still being done on items 9 and 10):

Component	*Approximate cost*
1. Video camera/recorder	$1,500
2. Microcomputer	2,000
3. Graphics display controller	600
4. Graphics display	250
5. Graphics printer	800
6. Graphics pointer (mouse)	150
7. Portable color monitor (optional)	300
8. Workstation (optional)	600
9. Video mixer, sync. separator	—
10. System	—

Methods

Image acquisition methods. A 6-foot target was constructed to serve as a scaling reference for the imaging system. The target was designed for height adjustment and with an optional mount allowing for attachment to tree stems. By including a reference of known dimensions in the camera's field of view, objects that are the same distance from the camera as the reference can be compared, scaled, and measured.

Imaging accuracy was determined by performing a 23-point calibration against a horizontal scale at a working distance of 23 meters. After digitizing the 23 stations on the scale, the digitized values were regressed against the scale values to quantify the error. Results show a standard error of 2.0 cm and a peak error of 4.3 cm. The video system can also scale objects at distances other than the reference distance. This is accomplished by adaptation of a method previously reported that used photographic images *(1, 5)*.

The capability for adjusting scale for different distances from the camera has important practical value. For example, when monitoring line fires, specifically headfires, elliptically shaped fire fronts are formed and are presented on the monitor as a two-dimensional silhouette of the leading edge of the fire. Although the leading edge usually occurs near plot center, exact location is difficult to predict when placing the reference target.

Figure 2—*Image analysis subsystem components integrated into a mobile work station.*

Our system allows the operator to locate a baseline at the ground level position of the flames' leading edge, and with appropriate computer graphic aids, the image can be rescaled for distances other than the location of the target reference.

Our current system is limited to fires in somewhat level terrain. However, work is in progress to develop methods for slope scaling.

Image analysis methods. The present system is capable of providing measures of flame length, height, angle, cross-sectional areas, and forward rate of spread. Work continues on flame depth and midflame windspeed.

Because fire is a transient phenomenon, computer measurement of video images is accomplished by freezing individual frames from the 30 frames per second taken by industry standard video cameras. Reducing the still frame images of fire into digitized form is accomplished by the microcomputer. Computer algorithms have been incorporated into the digitizer control program so that the operator may compute the desired parameters interactively rather than having to run a postanalysis. The parameters may be saved into a data set so that large groups of data can be compiled permitting a quantitative examination of the fire variability. This information can be merged with prefire and postfire site characteristics taken from within the camera field of view. Subsequent rigorous interpretation of fire effects with appropriate statistical analysis is thereby feasible.

System Evaluation

As a practical test, the imaging system was used recently in both lab and field experiments in connection with the study "Flame Characteristics of Wind-Driven Fires in Surface Fuels" by Nelson and Adkins *(8)*. Twenty-two fires in a laboratory wind tunnel (fig. 3) and eight field fires (fig. 4) were studied to determine relationships between flame characteristics and fire behavior. In these experiments the system demonstrated the ability to provide clear, well-defined images of flames from which measures of flame geometry were taken. A distinct advantage was noted in the ability to rapidly review the fires a number of times in contrast with past attempts to use subjective observations for behavior measurements.

The internal elapsed time feature facilitated identification of points of interest along the fire's path. Rate of spread was plotted over time to establish spread uniformity from digitized

values of traverse distance and elapsed time. With this system, Nelson and Adkins were able to verify Byram's *(4)* flame length-fireline intensity relationship for several of the fires studied, but noted a distinctly separate mode of flaming for the laboratory fires where fuel consumption was approximately 0.5 kg/m^2. Flames of relatively constant length, height, and tilt angle are associated with this mode of burning. If similar behavior occurs in the field, this effect may be of significance in the burning of young stands or 1-year roughs in which fuels are light. Estimation of fire intensity from flame length by the Byram relationship could be misleading under these circumstances. Results also show that fire intensity can be determined in the field by expressing flame length in Byram's equation in terms of tilt angle and height. This method may be useful when flame length is hard to estimate visually or measure remotely with an imaging system.

System evaluation continues at this writing on a fire study in cooperation with the National Park Service at Everglades National Park in Florida. It is our hope that simplified procedures can be developed so that other investigators will consider adopting this concept when attempting to define fire variability and when developing quantitative fire effects relationships. We are not implying that this system is needed for all fire research investigations. Rather, we are suggesting that documentation of the "fire treatment" process needs improvement, and this system is a step in that direction. With some minor refinements in software and hardware, all components should be readily available at a reasonable cost. We invite your inquiry and observations concerning possible future applications.

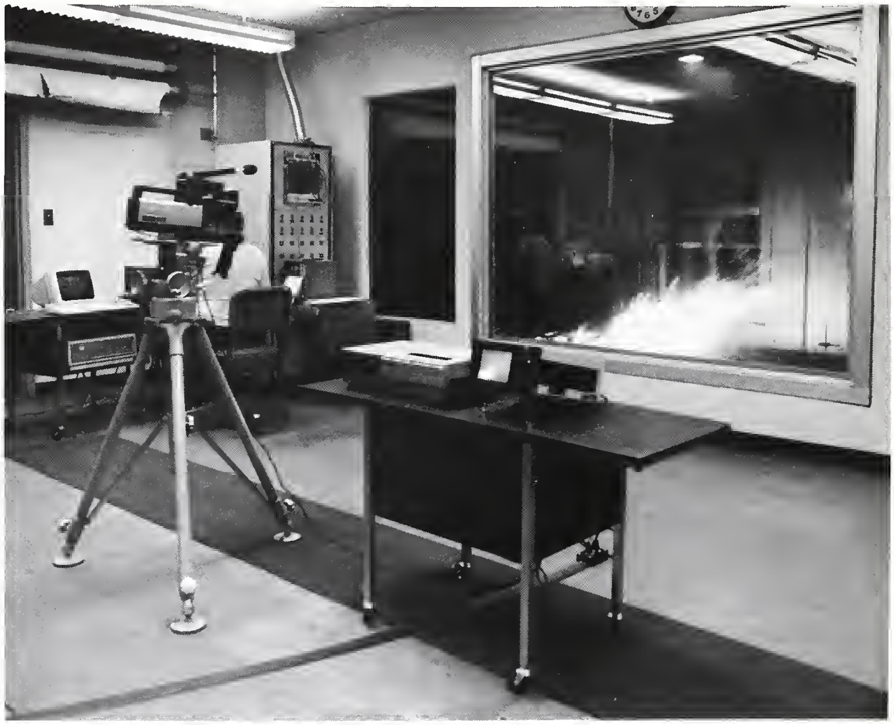

Figure 3—*Southern Forest Fire Laboratory wind tunnel. Small-scale fires can be burned under controlled conditions of windspeed, fuel moisture, and fuel loading.*

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Figure 4—*The image aquisition subsystem deployed in a field burning trial.*

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Economics of Fire Management

When a major forest fire is burning, the people trying to control it have a lot of factors to consider. They must use available personnel and equipment in a way that promises victory. But economics has a great deal to say about the quantities of people and equipment they can use. The amount of people and equipment used depends on the values that are being protected.

How much damage is a fire likely to cause? This is a question that fire management planners often have to answer, and researchers from the Pacific Southwest Station have been helping to find the right answer for individual sets of conditions. Wildfires sometimes destroy timber stands completely, but more often they cause partial loss and sometimes they even cause improvements. Some of the dead trees often can be salvaged; some of the live ones may have suffered only temporary setbacks. Other trees may not be damaged at all and many grow faster because competition has been reduced. How can all these situations be handled in a single analysis?

The researchers say that calculations of net value change provide the answers that are needed. The value of the stand after the fire can be subtracted from the value before the fire to estimate the net value change. A new procedure is being used in a fire management planning model under development at the Pacific Southwest Station. A sound basis for determining the appropriate values under protection should be one result of this work. ■

ICUF: A Procedure To Measure Prevention Successes

Earl Meyer and Duane Dupor

Forest fire specialists, Wisconsin Department of Natural Resources, Madison, WI

The success of a Forest Fire Prevention Program has always been difficult to measure. It is difficult to determine whether the reduction in fires is a direct result of your program or the weather. Wisconsin has developed a method that normalizes the weather.

Using Ignition Components

Forest fire specialists Earl Meyer and Duane Dupor developed a technique of using cumulative ignition components in relationship to the numbers of fires from any cause. By using historical weather data and fire reports, a fire district can determine what the average numbers of fires are for a given number of ignition components.

For example, Wisconsin wanted to lower the incidence of forest fires caused by debris burning by 15 percent over a period of years. We had to establish a base period from which to work. We had each of the 10 forest fire control areas add up the total number of ignition components for a 5-year period (1979–83), then divide that number by the number of debris-caused forest fires that occurred during the same 5-year period. The answer is the number of ignition component units per fire (ICUF) or a number that relates fires to weather on a fire district.

All a fire manager has to do is begin keeping daily cumulative records of ignition components and debris-caused forest fires each fire season. This will give him a timely indication of whether the number of debris burning forest fires has increased or decreased in relation to past fire and weather history. Prevention plans can then be adjusted accordingly.

Table 1—*Example of daily tally sheet used in Wisconsin ICUF program*

1 Date	*2* IC daily	*3* IC cumulative	*4* Areas ICUF	*5* Normal fires × .85	*6* Goal	*7* Cumulative actual fires	*8* Goal (+ or −)	*9* Planned action
3–1	20	20	50	.4	.34	1	+ .66	None
3–2	30	50	50	1	.85	1	+ .15	No
3–3	50	100	50	2	1.7	1	− .7	No
3–4	50	150	50	3	2.5	6	+3.5	Canvas Red Elm sub-div. one on one

Wisconsin has used this system for two seasons, and the results are encouraging.

One big advantage of this system is that it can be applied to any size fire area where fire and weather history is maintained. This allows that area to make comparisons with itself and not with other areas that have different weather, hazard, and risk conditions.

Considerations

This program depends on two important considerations:

(1) Historical fire weather data must be available. Fire danger must be measured every day of the fire season so a cumulative total can be calculated.

(2) Accurate fire cause investigation is necessary.

We feel that by using ignition component units per fire (ICUF), the fire manager can judge the effectiveness of his fire prevention effort. Although it has worked well for Wisconsin in measuring debris burning fire occurrence, it may also be effective in measuring trends of other fire causes.

Example

Using a tally sheet similar to table 1 should help the areas target their debris burning problem and aid them in reducing the debris-caused forest fires by 15 percent. Using the base year average 1979–83, enter that number for ICUF in column 4. The following example shows how the tally sheet can help when the dispatcher begins to take down fire weather information in the spring.

March 1 is the first day that weather information is being taken at station x. The date is entered in column 1. The IC for the day is 20—enter 20 in column 2. Since this is the

first day, the cumulative IC is also 20—enter that in column 3. ICUF has been entered in column 4. Dividing ICUF into the column 3 number produces the number of normal debris fires for the IC. Enter that number in column 5. Multiply column 5 times .85 to establish your goal. Enter that number into column 6. Column 7 contains the actual number of cumulative debris fires to date. Column 8 indicates whether you are above (+) or below (−) your goal. Column 9 indicates what action if any will be taken to bring the debris fires to acceptable levels. A simulated 4-day tally is given in table 1 to aid you in getting started. ■

Michigan Agencies Promote Wildfire Prevention

Over 11,830 wildfires burned in Michigan during 1984, resulting in untold damage to natural resources and property of homeowners. For years, fire prevention priorities have taken a back seat to emphasis on suppression. The Forest Service, Michigan Department of Natural Resources, and fire departments have had wildfire prevention programs for many years, but the level of activity generally depends on the individuals involved.

To help increase the activity level, the fire agencies in Michigan got together to determine what they could do to promote wildfire prevention. An interagency wildfire prevention team was formed in 1978 by representatives of the USDA Forest Service, and USDI Fish and Wildlife Service, and the National Park Service; and the Michigan Department of Natural Resources. As the dialog continued everyone felt that the grass roots firefighters should be included in the group. So, representatives of the Michigan State Fire Chiefs Association, the Michigan State Firefighters Association, and the State Fire Marshal's Office were asked to join in the fire prevention effort. That brought all the major fire agencies together so that the prevention issues could be specifically addressed.

Committees have been established to work on individual issues facing the group, such as communications, data, and training. Today, the Interagency Wildfire Prevention Group is actively pursuing the goal of reducing the number of grass and brush fires throughout Michigan.

A program targeting fire-prone property was developed, an action plan is being used to funnel local wildfire danger information into one place for compilation and distribution to the news media, a Spring Wildfire Prevention Week was organized and held, and a Wildfire Cause Investigation course was given. Many fire prevention messages have been used by radio, television, and the newspapers. Wildfire prevention training materials are being gathered and cataloged for use by member agencies. This material is maintained at the DNR office in Lansing.

To help with the cost of wildfire prevention materials and activities, a special revolving account has been established. Member agencies may voluntarily contribute to the fund as their budget permits. The three national forests contribute on a percentage basis out of their prevention budget.

The Interagency Wildfire Prevention Group has made great progress in getting the main fire agencies involved in active fire prevention. Everyone has the same ultimate goal, but we tend to spin our wheels a lot. By pooling our ideas and resources and then pulling together, much can be done at the ground level to prevent wildfires. The ideas must be put into action; a fire prevented is a fire that will never need to be suppressed.

Arthur Sutton
Executive Secretary,
Interagency Wildfire Prevention Group, Forest Management Division, Michigan Department of Natural Resources,
Lansing, MI ■

Fireline Explosives—A Second Look

Dwight S. Stockstad, Troy W. Kurth, and Richard J. Barney

Respectively, research forester (retired), fire control section leader, and research team leader (retired), USDA Forest Service, Missoula, MT

Fire control agencies have periodically experimented with explosives for fireline construction, with particular emphasis occurring during the 1970's. The Missoula Equipment Development Center (MEDC) experimented with linear explosives (fig. 1) for use in fire suppression operations early in this period. This experimentation led to the development of a system that enables small, highly mobile crews to rapidly construct fireline.

A promising linear configuration explosive called Prima-cord was developed in cooperation with the Ensign-Bickford Company, Simsbury, CT *(1)*. Field tests at MEDC and extensive safety tests at the Naval Weapons Center, China Lake, CA, led to the approval of the Prima-cord fireline cord for fireline use by the Forest Service, U.S. Department of Agriculture. Prima-cord consists of an explosive core of PETN (pentaerythritol tetranitrate) encased in a fabric braid and a plastic jacket. DAP (diammonium phosphate) surrounds the explosive core, extinguishing the exploding fireball before it reaches the flashpoint of surrounding vegetation. Prima-cord is manufactured in a four-strand and a seven-strand configuration. Use of the four- or seven-strand cord depends upon the type of fuel present.

Another form of linear explosive is Water-Gel *(2)*. The explosive ingredient is ammonium nitrate, which is relatively inexpensive and much safer to handle than dynamite. A fuel sensitizer, thickeners, and a cross-linking agent are added to form a gel. The material is encased in a plastic tube resembling a sausage, about 1½ inches in diameter and 100 feet long. Although the casing is relatively tough, it is subject to tears and punctures if not handled carefully.

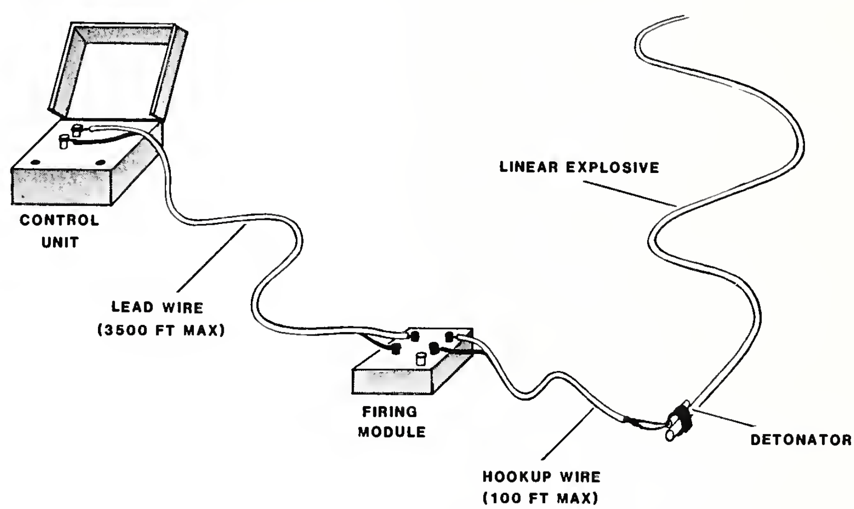

Figure 1—*Linear explosive charge attached to exploding bridgewire (EBW) firing system.*

Both Prima-cord and Water-Gel are detonated by an exploding bridgewire system (EBW) that offers maximum safety for blasting operations (fig. 2). Detonation requires a precisely timed electrical charge from a special firing set. The EBW cannot be set off by stray electrical currents, static electricity, or radio transmissions, as can standard electrical caps.

Missoula-based smokejumpers first used air-dropped fireline cord with good results on the Outlaw Fire in the Idaho Panhandle National Forest in 1974. Since that time, use by smokejumpers has been limited; however, when this technique has been used, results have been excellent. In preparation for the 1983 fire season, the Forest Service Northern Region increased its fireline explosive cord stock to 30,000 feet. In addition, a contract was enacted for additional fireline cord. Fireline explosive will be routinely used where 20 or more smokejumpers are dropped on initial attack.

Forest Service use of fireline explosive in other areas of the United States has been satisfactory, although limited. The Bureau of Land Management has had excellent results with fireline cord in Alaska. About 15,000 feet was used in wildfire suppression during the 1981 fire season. Some 74,000 feet of cord was stocked for use during the 1982 fire season. A

"Fireline Explosive Use Policy" section was included in the 1982 Alaskan Fire Suppression Field Reference Handbook.

The State of Washington Department of Natural Resources has been a leader in the use of fireline cord to fight wildfires. A standard issue of 5,000 feet of explosives is a part of the supplies sent to a project-sized fire on State lands. Approximately 81,000 feet of fireline cord was purchased in Washington from 1978 and successfully used on nine project fires. The State of Montana is also developing capabilities in this area.

Figures 3 and 4 show the excellent quality of constructed fireline obtained in two different fuels. The line width to mineral soil averages 12 inches. The soil cast to either side adds at least an additional 2 to 4 feet of effective line width. The dusting effect will reduce the intensity and spread rate. The more moist the ejected material, the more effective it is in slowing and halting the active flame front.

Water-Gel linear explosive (ammonium nitrate with an added sensitizer) is commonly used in constructing firelines for prescribed burns. An average of over 90,000 feet per year of Water-Gel explosives has been used in the Forest Service Northern Region for the past 3 years. This explosive has not been approved by the Forest Service for use on wildfires, pending tests by the Naval Weapons Center. Results achieved on prescribed fires with Water-Gel are comparable to those achieved with Prima-cord.

Figure 2—*EBW control unit (right) and firing module.*

Despite good operational results, application of fireline explosive technology has been slow. A general survey by the Northern Forest Fire Laboratory of explosive use by suppression organizations in the Western United States revealed little use of the fireline cord during recent fire seasons. One reason seems to be the lack of first-hand experience and understanding of when, where, and how to use fireline explosives. The relatively small number of personnel trained as fireline blasters has, in some areas, discouraged use. The Northern Region qualified 70 fireline blasters for the 1983 season. Personnel trained in the use of explosives are most enthusiastic about its use. Blasters are being trained in increasing numbers, so this handicap should soon be eliminated.

The time required to deliver explosives to the fire is also an apparent deterrent. A lack of proper storage facilities in outlying areas contributes to the delay. Fire specialists commonly fear that explosives will not arrive in time for efficient use. Early anticipation of the need for fireline explosives

Figure 3—*Fireline blasted in moderately open ponderosa pine stand with light ground fuels, before detonation and after detonation.*

on a going fire would assure availability on the fireline at the most desirable time. A powder cache adjacent to the Missoula Aerial Fire Depot is being constructed to speed up delivery in the Northern Region. Current plans call for a 15-minute getaway time for parachute delivery of blasting crew and fireline explosives to a fire. Fireline explosives may also be air dropped to qualified fireline-blasting personnel already on the ground.

Lack of field application guides and related information on fireline explosives has also limited their use. Even trained blasters have usually had experience in only a limited number of fuel, cover, and terrain types, and may be hesitant to use explosives in unfamiliar situations. Many fire specialists have had little or no experience in the use of explosives. A guide to proper use of explosives under various conditions would help overcome this obstacle.

Fireline explosives may seem prohibitively costly for wildlife suppression, but the small number of personnel needed to blast a fireline and the speed at which it can be done more than offset the cost of the explosive. Approximate 1983 FOB costs for Ensign-Bickford fireline cord is $3.15 per foot. The Ireco Water-Gel costs about $0.55 per foot. The exact cost depends upon the amount purchased and the cost of delivery. The increasing costs of labor and the difficulty of securing trained workers are growing problems that outweigh the cost of explosives. However, depending upon crew size, fuels, and other factors, explosives can be very competitive in many cases and show distinct advantages in others. Most

fires in the Northern Region can be held and mopped up with a relatively small force once a fireline has been constructed.

Current research at the Northern Forest Fire Laboratory in Missoula has three objectives. First, establish the actual line dimensions accomplished by blasting in various fuel and ground conditions. Second, determine the rates and unit costs of blasted fireline. (The first two accomplishments will allow a valid analysis of blasting as compared to other line-building techniques.) The third objective is to develop field guides for operational use of fireline explosives.

Fireline explosives provide an excellent tool for suppressing wildfires. Use has been limited because of several factors, all of which can be eliminated through training programs, development of field guides, certification of fireline blasters, and resolution of transportation and storage problems. Removal of these limiting factors should establish routine use of fireline explosive technology.

Further information on supplies, training, and related information can be obtained by consulting the two references cited or by writing the USDA Forest Service, Equipment Development Center, Missoula, MT 59801. ■

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Figure 4—*Fireline blasted in heavy* Ceanothus *brush, with numerous downed logs, before detonation and after detonation.*

GSA Reorganization

Ed Wirt

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No doubt many of you have heard one or more of the many rumors concerning the General Services Administration (GSA) support of the wildland fire program. It seems that if you don't like the rumor of the moment, just wait awhile and perhaps the next one will be more to your liking.

The GSA budget, like those of other Federal and State agencies, is being reduced. As a result, the Federal Supply Service (FSS) of GSA, which operates the National Wildfire Suppression Equipment program, is being reorganized. This reorganization will result in the closure or reduction of operations in some GSA regions.

The purpose of this reorganization is to enable GSA to continue support of the wildland fire community with a streamlined but more efficient organization.

The changes that will affect the wildfire management community are already taking place within FSS. First, overall management of the National Wildfire Suppression Equipment program is being transferred from FSS Region 8, Denver, CO, to FSS Region 7, Ft. Worth, TX. Second, FSS depots in FSS Regions 8 and 10, Auburn, WA, are being closed and the fire inventories located in these depots are being relocated in the FSS Region 9 depot at Stockton, CA, and to a lesser extent in the depot at Ft. Worth. Third, procurement of items for the wildfire program will take place within regional commodity centers with the responsibility to procure items on a national basis.

The FSS Commodity Centers will provide more efficient utilization of the resources available. Each will provide the full range of services such as procurement, inventory management, technical engineering, and requisition processing for all items managed by the center. The movement of FSS to regional commodity centers will reduce the number of procurement centers with national procurement support commitments from the present 16 to 8 by the end of 1986.

The Ft. Worth commodity center will manage all fire items on a nationwide basis and procure two-thirds of the items. The remaining fire items will be procured by the commodity center with national procurement responsibility for those items. The GSA Wildfire Suppression Equipment and Supplies Catalog will be continued by the Ft. Worth commodity center. Ft. Worth will provide the full range of services that pertain to the catalog ranging from addition and deletion of items to publication and distribution.

GSA will maintain adequate supplies of needed fire items, and there are no changes required in ordering procedures. We will be as ready to supply you for the 1986 fire season as we were for the 1985 fire season.

The position of National Wildfire Suppression Coordinator will be established in Ft. Worth, and will entail responsibilities in addition to those directly involving wildfire suppression. The coordinator will maintain coordination with the Boise Interagency Fire Center, Boise, ID, and closely monitor matters that have an impact on the wildfire community's supply needs.

Although this article may not have answered all your questions, it is hoped that it has been informative and that you consider it to be of value to your operations. Additional information will be furnished as it becomes available. ■

Underburning May Reduce Productivity in Ponderosa Pine Forests

It is widely believed that prescribed fires of low intensity beneath trees 25 feet tall or more increases their growth. Such burning, it is said, removes competing vegetation and increases supplies of water and nutrients for the trees. You can imagine the surprise of Pacific Northwest Station scientists, therefore, when they examined the growth after some fires under ponderosa pines in the interior West. Unexpectedly, they found that trees grew more slowly during the first 4 years after the fires than before. Height growth was down 18 percent and the increase in stem cross-sectional area (called basal area) was down 16 percent.

At this point, the scientists are unsure of the causes for the decrease in growth, so they are conducting additional studies. ■

Science Has Got Its Hands on Poison-Ivy, Poison-Oak, and Poison-Sumac[1]

Noel Vietmeyer

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In the summer of 1977 parched slopes of the Los Padres National Forest near Monterey, CA, were torched by lightning. For 3 weeks the Forest Service battled the flaming brush and trees.

But the Marble Cone Fire eventually spread to cover nearly 289 square miles of mountainsides, and the situation became desperate. "We were trying to fight one of the worst fires in memory and we couldn't keep a full crew on the fireline," recalls one forest engineer. "Guys were streaming out of the hills with their eyes running. It was California's second largest wildfire, with high risks of going completely out of control, and almost a third of our men had to leave the line with injuries caused by poison-oak!"

Poison-ivy is found in most of the United States (fig. 1–2), the relatively rare poison-sumac in the East, and poison-oak in the West (fig. 3–4). There is also a southeastern species of poison-oak locally known as Eastern poison-oak. Wherever they occur, these plants are the nightmare of gardeners, the scourge of hikers, and the curse of campers. At least 110 million Americans are clinically sensitive to the chemicals they contain; some 23 million are so sensitive that after even brief exposure they require a doctor's care. For millions of Americans these innocent-looking, rather attractive plants have made the outdoors a place of menace. To avoid contact, they have been forced to abandon their gardens, give up on picnics, and avoid the summer woods like the plague. Others venture out swathed in protective clothing, as if going off to battle, and on becoming casualties spend day after itchy day smearing their bodies with brown laundry soap or other home remedies. For all of these sufferers relief—at least in part as a result of the Marble Cone Fire—may be in sight.

Figure 1—*Poison-ivy in Florida.*

Unrelated to normal ivy or oak, the plants are members of the cashew family and are related to the cashew itself, the mango, and the lacquer tree of Asia. (Lacquer is a varnish made

[1]Reprinted from Smithsonian Magazine: Special thanks to the author for permitting this reprinting.

Figure 2—*Poison-ivy in Idaho.*

from this tree's poison-ivylike sap, which can also cause a rash.) Native to the United States, Asia, and Central America, these plants are almost unknown in other parts of the world. In the last century, for example, English visitors were amazed at the beautiful fall colors of poison-ivy and took some home. Because it was called "ivy," they planted it. Soon thereafter a British medical journal reported a new disease contracted only by women, who did the gardening, and concluded that it was a "hysterical rash"!

All parts of the country except Hawaii, Alaska, and some of Nevada contain poison-ivy, poison-oak, or poison-sumac. Poison-oak is actually one of the most widespread shrubs in California. Deer, cattle, goats, and other herbivores browse the nutritious foliage without apparent ill effects, but most humans touch the plants at their peril. And firefighters fear these vines and shrubs more than almost anything else. Breathing smoke from burning poison-ivy or poison-oak can have fearsome results: head-to-toe dermatitis, fever, horrendous lung infections, malaise, and even death when the throat swells shut. Moreover, firefighters cannot avoid the plants. At night, they cannot see them, and, besides, firelines must be cut whether or not any patch of vegetation is in the way.

More Trouble Than Cuts and Contusions

Jerry Oltman, a project leader for the Forest Service Equipment Development Center at Missoula, MT, was not at the 1977 Marble Cone Fire; he lives in Montana, 800 miles away. But his office designs and builds equipment for the Forest Service, and he decided that it should do something to avoid a repetition of the doleful experience. "Poison-ivy and poison-oak cause ten percent of all the Forest Service's lost-time injuries—almost twice as many as cuts, abrasions, and contusions combined," he says. "I figured that if we could find a way to reduce these injuries by even a small percentage, it would pay for itself many times over."

Initially he tried to encourage Federal agencies and pharmaceutical companies to lead a broad-based effort to develop a skin-patch test kit for sensitivity to the plants as the first step to reduce injuries. None showed any interest. To them, extensive poison-ivy research seemed neither a national priority nor a commercially enticing prospect. So Oltman, a forester who has never had a poison-ivy outbreak in his life, and who lives in

one of the few parts of the country that has none of the poison plants, took on the daunting task himself.

First he approached William Epstein, the Nation's most experienced poison-oak researcher. A dermatologist at the University of California Medical Center in San Francisco, Epstein is perhaps the only person in the country who speaks enthusiastically about these plants. His exuberance bursts out in lively staccato: "Poison-ivy and poison-oak are by far the major cause of allergic contact dermatitis in the United States; more people suffer from them than from all other allergic skin diseases combined. . . . No one counts the number of cases, but there are probably at least ten million a year nationwide. Poison-oak and poison-ivy are possibly the greatest cause of worker disability in the Nation; each year may bring more than 140,000 cases in the workplace, causing perhaps more than 152,000 lost workdays!"

Poison-ivy, poison-oak, and poison-sumac all contain a heavy oil called urushiol (pronounced *oo-ROO-she-ol*). It is clear, gummy, so incredibly reactive that a pinhead amount can cause rashes in 500 sensitive people, and so long-lasting that botanists have received serious dermatitis from plant samples stored away for more than a century. In one reported incident, lacquer from a Chinese jar, which had been buried for about a thousand years, caused dermatitis.

A Skin Test To Measure Sensitivity

With a contract from Oltman, Epstein and his colleague Vera Byers developed a test for determining a person's sensitivity to urushiol. "Most people actually don't know how reactive they are because the last time they had a dose was in childhood," notes Epstein. "But the sensitivity changes with time; as some people get older they get less reactive, particularly if they never encounter the plants. It works the other way, too. People used to wading unscathed through patches of the plants can suddenly break out."

The skin test is similar to the one used for detecting TB exposure. A small, standardized drop of dilute urushiol is placed on the arm. Seventy-two hours later, depending on the person's reactivity, there will be nothing, a red spot, a red spot with swelling and itching, or a red spot with blisters. It is simple enough for anyone to do, it comes with a little tube of cortisone gel to take away the rash, and the amount of urushiol is so small that the rash will not spread.

"For the first time we are getting baseline information on just how sensitive people really are," reports Epstein. "Between 15 and 25 percent of us are essentially immune, 25 percent are mildly sensitive and don't normally develop severe reactions, 25

Figure 3—*Poison-oak in California.*

Figure 4—*Poison-oak leaflet.*

to 30 percent are moderately sensitive and break out significantly with the amount of urushiol found in one leaf, and 10 to 20 percent are so exquisitely sensitive that less than one leaf produces intense dermatitis."

Last year the Forest Service used the skin-patch kit to advise its firefighters on their susceptibility. Next year Oltman hopes to have it produced commercially. "One day you might see it in sporting goods stores," Epstein speculates. "People going fishing, hunting, or whitewater rafting could find out how sensitive they are before setting out, and companies could identify and provide special protection for workers most likely to suffer massive dermatitis in the woods."

The test kit doesn't help once an exposure has occurred, but advances in conquering the reaction are coming from immunologists. Urushiol, despite the plants' names, is not a poison; it causes an allergic reaction. As with other allergies, people are born without any sensitivity to urushiol. Babies, for instance, rarely get the dermatitis. Between the ages of 5 and 10, however, most children become sensitized, and from then on their immune system is reactivated whenever they again come in contact with the plants, even if it is 20 years or more later. It is not known how many exposures will cause the first response, but after the first response mere traces will again trigger the reaction.

Within minutes of contact, the oil urushiol penetrates the outer skin layers and begins chemically binding itself to skin cells. The body sees the combination of an urushiol molecule piggybacking on a skin cell as a foreign intruder. The immune system rushes large white cells called macrophages and T-lymphocytes to destroy the affected skin cells.

"It's the body's own overreaction that causes the complications," explains Epstein. "In sensitized persons the area fills up with the white blood cells and they release so much cell-destroying toxins that they tear apart even the skin itself. That's what produces the blisters and suppurating sores."

Research

However, the fact that urushiol generates an immune response gives researchers a chance to deliberately suppress the body's response. And this has now been accomplished experimentally.

Mahmoud ElSohly, a chemist at the University of Mississippi, has created a "masked" form of urushiol that binds less to the skin. Experiments with guinea pigs show that it can be

safely swallowed. When it is absorbed from the digestive tract, the liver strips away the chemical disguise, thereby releasing urushiol into the bloodstream. This release causes an entirely different kind of response from the immune system. Sensing the invader, the immune system may manufacture suppressor cells and chemicals; those that remain in the blood desensitize the person so that upon later contact with poison-ivy or poison-oak the body's response is muted.

"Urushiol is released where it is effective," explains ElSohly. "We can use fairly large doses, there appear to be few side effects, and the immunity is developed quickly." But the procedure is still experimental; clinical trials with humans at Epstein's laboratory in California as well as in Pennsylvania have not yet shown the effectiveness of this vaccine at safe doses.

Epstein and his colleague Vera Byers are developing their own poison-ivy vaccine in a related way. They use a modified form of urushiol that is unreactive on skin (and so doesn't have to be chemically masked), but that creates an immune response when small amounts are swallowed. "It desensitizes animals," noted Byers. "Now we're preparing to try it in humans."

Poison-ivy pills that immunize adults for a year and children for the rest of their lives might seem like the ultimate solution, but there is also hope for other forms of relief against the plants.

For instance, a scientific team at the Oregon Health Sciences University in Portland has developed a set of chemicals that shield the skin from urushiol. "We think people would appreciate something like a suntan cream that could be applied before going into the woods," says team member Susan Orchard. "Already we have found a preparation of organic salts that protects all test subjects from dermatitis for 8 to 12 hours when droplets of urushiol are taped onto their skin with a patch. It also protects about one-half of the volunteers for 48 hours."

With all this progress in research, some hoary folk beliefs are being debunked or confirmed as fact. For example, scientific evidence now indicates that it is impossible to contract dermatitis just by standing near the plants. Urushiol is a heavy oil that does not vaporize. Moreover, it is in canals inside leaves, stems, and roots; an undamaged plant has no urushiol on its surface.

The leaves are easily bruised, however, and insects chewing on them can produce spots of urushiol on the surface. Moreover, direct contact with the plant is not a prerequisite for getting the dermatitis. Shoes, clothing, tools, pets, or golf balls that have been through the rough can all transmit the sap to people. And they may cause rashes days, months, or possibly years after they touched the plants.

Today, the myriad of preventives and cures that have been proposed in the past can be better assessed. Home remedies, patent medicines, and "guaranteed" cures of the past have included bathing in horse urine or bleach; cleaning the skin with gasoline, morphine, gunpowder, buttermilk, marshmallows, or strychnine; drinking photographer's hypo; or rubbing on ammonia, mustard, Lysol, hair spray, clear nail polish, meat tenderizer, or toothpaste. All are probably useless, some even dangerous.

Drinking milk from goats that have grazed poison-ivy or poison-oak has long been claimed to give immunity. (Goats have such an appetite for all parts of the plants that, given time, they can eliminate them from a pasture.) "This is one folk remedy that probably works, although it never has been tested," says Vera Byers. "There's something magic about oral doses of urushiol oil, and goat's milk probably has traces of it. If you drink goat's milk you're probably doing about the same thing we are in our vaccine work."

Although we are now getting such practical insights into this affliction, Harold Baer of the Food and Drug Administration—himself a longtime poison-ivy researcher—cautions against too much optimism. "There have been innumerable remedies proposed in the past, and few have withstood the test of time." What is different today, however, is that researchers have designed experiments that provide fundamental and

reproducible information under controlled conditions. With these advantages, more reliable weapons are being forged.

"The poison-oak story is beginning to make more and more sense," says Jerry Oltman, who now looks back on the Marble Cone Fire with a different perspective. "Very little of it is science fiction anymore." ■

Additional Information

The USDA Forest Service has published several booklets on this subject:

- Poison-Oak and Poison-Ivy Dermatitis.
  Booklet no. 8167–2803 (August 1981)
- Preventing and Treating Poison-Oak and Poison-Ivy.
  Booklet no. 8167–2503 (August 1981)
- Developing Poison-Oak/Ivy Test Kit for Forestry Field Workers.
  Booklet no. 8367–2204 (October 1983)
- Testing Materials That Bond with Poison-Oak/Ivy/Sumac Urushiol.
  Booklet no. 8467–2203 (August 1984)

These booklets are available from:
USDA Forest Service
Missoula Equipment and Development Center
Missoula, MT 59801

Living More Safely in the Chaparral-Urban Interface

Fires sweep through communities, houses slide down hills, debris covers roads, and flash floods create havoc. These hazards of living in the brush-covered foothills and mountains of southern California often make the front pages of the Nation's newspapers.

In recent years, urban development has extended relentlessly into rural areas around many of the Nation's largest cities. Where the topography is relatively flat and open, this encroachment presents no great difficulty. However, where cities are surrounded by steep, brush-covered slopes, development has all too frequently resulted in loss of lives and property.

The brushland sequence of fire, floods, and erosion is particularly common in chaparral areas of southern California. Chaparral is a plant community in California that has adapted over millions of years to summer drought and frequent fire. Similar vegetation is found in regions of Mediterranean climate throughout the world. The plants grow dense and luxurious, and when this growth is followed by dry, windy winters, hazardous fire conditions are created. Urban encroachment accelerates the cycle and adds to the potential for tragic wildfires.

The Forest Service Pacific Southwest Station has published a guide, entitled "A homeowner's guide to fire and watershed management at the chaparral-urban interface," to promote living more safely in the chaparral-urban interface. This guide is available from the Los Angeles County Fire Department or from Information Services, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

It describes preventive maintenance measures that should help reduce the damage from fire and flood. The information provided is addressed to homeowners, home buyers, developers, landscape architects, land use planners, wildlife managers, zoning agencies, city and county boards of supervisors, and other interested persons. ■

Crew Mobilization: Where Do You Start?

Stephen W. Creech

State fire coordinator, Indiana Department of Natural Resources, Division of Forestry, Martinsville, IN

So you want to be part of a fire crew on an out-of-State assignment? In 1985 there were 50,000 such people. When you are talking about mobilizing thousands of firefighters on short notice, everyone must be fully prepared. Are you really ready? Can you meet transportation deadlines? Are you fully qualified and fully equipped? Are your job responsibilities and personal commitments in order? Are you healthy? You may only have a few minutes to decide the answers to these and many other questions.

What follows is intended to help the crew boss/strike team leader, squad boss, veteran or rookie firefighter prepare for an out-of-State fire mobilization. The key to success, in this situation, is to have as many of the answers prior to the call as possible. In essence, the only task a crew leader should have, once the fire call is received, would be to fill the manifest with the names of those firefighters who can leave what they are doing for an extended period—a seemingly easy task, but the one requiring the most time.

Speed and safety are two key elements in any mobilization. One small bottleneck and an entire operation can come to a grinding halt. And because we are dealing with *wildfire*, the situation can become increasingly worse in a very short period of time.

Back at your home unit, whether that is a State, a park, a reservation, or a forest, lies the cornerstone of the entire mobilization concept. Lack of proper planning here can take away the effectiveness of rapid deployment. This is beginning to sound like a military operation. Well, isn't that basically what is happening? The only difference is the enemy is wildfire. There are certain things that can be done to assure a smooth, safe, and rapid mobilization.

First, let's look at what these home units can do. If the goal is to put together a qualified fire crew then a good place to start would be with those individuals who have met the requirements—in our case, personnel with red cards. Once the call has been received to pull a crew together, it is too late to start looking for possible inductees. To maintain an active roster it will be necessary to annually administer the physical test (step-test or alternate run), issue red cards, and update training. As personnel qualify and are placed on the roster, they should be provided with an information packet that explains the program and includes a needs checklist. Plastic cards are available that briefly describe a suggested gear pack. A crew roster should be maintained with the names, addresses, home and work phone numbers, and qualifications (red card or not) of all interested personnel. Copies of this roster should be in the hands of several individuals. At any given time one or more of the leaders may be out of contact. In addition, the list could be divided so that one person would have only 10–15 names to contact.

People do not like to go to work thinking that they will be home by 5 p.m. only to find out they are part of a fire crew that may not be home for 2 or 3 weeks. It won't always be feasible, but when possible keep personnel aware of the fire situation. Early communication can make a mobilization run much smoother and shorten transportation times immensely.

Because of safety requirements and the need for uniformity, crews can no longer wait until they get to the fire to get personal equipment. For that reason it is now essential that a fire cache be maintained, at a central location, that is equipped with all the required personal safety gear. This should include fire shelters with case, Nomex trousers and shirts, hardhats, hearing and eye protection, gloves, first-aid kits, and canteens. These items will provide you with the necessary safety equipment required in most areas. It is also very helpful if personal gear packs are available. The gear packs make baggage handling easier and help personnel stay within the 35-pound gear weight.

The call we have all been waiting for has finally come. Before we start down the active roster we need to make some key decisions. First, the decision must be made concerning who will serve as leaders. Crew bosses/strike team leaders and squad bosses must be selected from those that are qualified. These individuals are the first ones contacted. Next there should be a mixture of veterans

and rookies. A good rule of thumb would be to not have more than one-third of the crew as first-timers. Decide whether the crew will be pulled together at a central location or will they proceed directly to a transportation pickup point. Based on the mobilization time, will it be necessary to provide meals and lodging? Will it be necessary to arrange ground transportation? Now the list can be divided, and the calling begins.

If you are one of the lucky ones and have received a call to be part of the crew, you must now make some rather hurried decisions. You need to consider: your health, family and professional commitments, can you meet the mobilization deadlines, can you be gone for 2–3 weeks, who will take care of the dog—the list can go on and on. It is better to say "no" this time than to have to try to get home from a distant fire camp. Unforeseen emergencies are allowable, but prevention is still the best policy. If you have said "yes" you must now proceed to the preplanned mobilization point. Do so safely. You are not of any use to the crew if you do not arrive in peak condition.

We will now assume that the crew has assembled at a central location. A check must be made of the following items:

a. *Boots.* The footgear should be of the approved type and in good condition. Don't count on being able to obtain a new pair once on the fire.

Fire crew arriving at Boise Interagency Fire Center, ready for action.

b. *Allergies.* Identify the firefighters that are allergic to environmental factors or substances that might be encountered. Allergic reactions could be to stinging insects, poisonous plants (e.g., poison-ivy, oak, and sumac), pollen, foods, medicines, or other substances. These allergies should be recorded and any necessary medications carried.

c. *Medication.* Make a list of all prescription medication and be sure that it is in fact prescribed for that individual. If there is any question concerning the effects of medication as it pertains to personal performance, consult a pharmacist. If there is any question, have the individual wait until next time.

d. *Gearpacks.* Make sure that the packs are within the weight limitations. Gear weight should not exceed 35 pounds per individual. (Note: total crew weight should not exceed 4,800 pounds.) Briefly go over the suggested list of gear. There may still be time to find replacements. Now is the time to hand out the personal protective gear from the fire cache. Make sure all crew members have their complete allotment.

e. *Crewperson weight.* Weigh the individual, fully clothed, and then with the gear pack. It is a good idea to record these weights and tape them to the individual's hardhat. This can greatly facilitate air transportation, formation of helitack crews, etc.

f. *Forms.* Be sure that you have filled out all the necessary forms and that you have copies of required documents, such as cooperative agreements. *Each* crewperson should fill out an emergency contact information form. One copy of this form should remain at the home office and a copy should be retained by the crew boss/strike team leader.

If time permits, there are two more areas that should be covered. The first is to conduct refresher training on the use of fire shelters. A review of recent shelter deployment situations indicated the need for more hands-on training in the safe and proper deployment of the fire shelter. The last thing that you can do is to go through a briefing. The briefing should be factual, not speculation, and should be used to put everyone on common ground. Use this time to help put the rookies at ease. Try to think back to your first out-of-State assignment. A reminder of the "10 Standard Firefighting Orders" and "13 Situations That Shout Watch Out" is a good way to end.

Ground transportation has now arrived, and everyone is ready to embark on what may turn out to be the adventure of a lifetime. ■

Personal Gear Checklist for Crews on Fire Details

Needed

*Nomex shirt and Nomex trousers
*Fire shelter
*Hardhat with chinstrap and headlight clips
*Boots, heavy duty, lace in accordance with approved Guidelines for Boots for Firefighting
*Gloves, leather or equivalent, unlined
*Interagency Fire-Job Qualification Card
Duffel bag or large packsack
Socks; heavywork, wool (6 pr) light inner, cotton (6 pr)
Sweater or sweatshirt (substitute for light jacket)
Pants, cotton, work, cuffless (2 pr)
Shirts, cotton, work, long sleeved (2-4)
Underwear, 100% cotton (4 sets)
Handkerchiefs (4) (include bandana size)
Towel, wash cloth, soap
Toilet kit with safety razor
Toothbrush, toothpaste
Chapstick, foot powder
Watch
Cash ($25–50)

Optional

Pocket notebook, ballpoint pen
Small flashlight for camp use
Shoes or sneakers for camp use (avoid slippery soles)
Pocket compass
Pocket knife
Eyewash
Long underwear (for cold night sleeping)
Soap, laundry, small box

*Mandatory Fireline Items July 1985
The Crew Boss should carry a copy of the cooperative agreement with the Forest Service

Alaska Division of Forestry Goes TROLLing

Ron Hanks, John Warren, and Dennis Pendleton

Senior aviation officer, Alaska Division of Forestry, Anchorage, AK; electronics engineer, USDA Forest Service, Boise Interagency Fire Center, Boise, ID; fire management group leader, USDA Forest Service, R-10, Juneau, AK

Visualize a cool Alaskan summer morning: Salmon are migrating to spawning grounds, and fall rains have not yet muddied the crystal-clear runoff from winter snows. As you board the bright yellow and white aircraft, a tinge of woodsmoke accents the crisp air and you know it's a good day for trolling.

If your vision carried you off to a remote fishing spot you haven't heard of the TROLL system being used by the Alaska Division of Forestry (DOF). TROLL stands for Thermal Recorded Observation and Loran Locating and is a new system used for plotting fire perimeter maps and for reconnaissance of wildfires.

The concept was originally conceived in response to the need for increased surveillance of "limited action" fires, which are now quite commonly a part of the State's fire management scheme. Large parcels of land have been placed in "limited", or "modified" action categories for the purpose of making the most of the natural fire regime in the Alaskan bush. Remote lightning-prone areas can then experience a natural recycling of wildland habitat by fire.

After 2 years under the newly developed fire management format it was obvious that intelligence gathering on multiple fire occurrences was difficult at best. Reconnaissance was curtailed by dense smoke, long distances, and the lack of geographic references needed for accurate mapping. Something better was needed to reduce risk, and in the fall of 1984 a new project got underway.

Designing the System

The TROLL project was initiated with several considerations that ultimately determined the type of equipment to be used. Overriding the intention of making the system operational by the following spring were the realities of making staff available to work on a dedicated basis, a limited budget for equipment purchases, and lack of proximity of resources for the design and application of an aerial surveillance system.

With these complications in mind several management decisions were made to further define the scope of the project.

First, all equipment utilized would be commercially available. This would decrease delivery time, improve servicing of components, and reduce overhead costs. The next decision was in favor of forward looking infrared (FLIR) in lieu of more expensive line scanners or sophisticated IR cameras. FLIR was a compromise in some aspects but later proved to be quite capable of providing excellent results.

Finally, it was decided that the North American T-28B Trojan aircraft being operated by DOF was best suited for the reconnaissance mission. It was particularly practical because of long range, high cruise speed, maneuverability, and excellent visibility obtainable from the aircraft. Helicopters were not feasible because of logistical problems in monitoring a large protection area.

The North American T-28B selected for this reconnaissance project is only one of a small fleet of seven T-28's that are an integral part of the aircraft pool used by the Alaskan Division of Forestry. These ex-Navy aircraft were acquired by Region 10 State and Private Forestry through the Federal Excess Personal Property Program and put on loan to the State for deployment in their fire management system.

The T-28 had previously been outfitted with new avionics including 9600 channel FM radio capability to facilitate interagency operations, but more importantly Loran-C navigation was installed, which provided a means of acquiring latitude-longitude coordinates, as well as a multitude of other navigational data that would prove to be an asset to acquiring mapping information.

After the aerial platform and navigational difficulties had been resolved, the next obvious hurdle was to select appropriate infrared equipment that would lend itself to monitoring fireline activity. Assistance was received from the USDA Forest Service Advanced Electronics System Development Unit (AESD) in Boise, and by February 1985 the proper equipment had been acquired.

A Cooperative Effort

Both agencies by this time had agreed that benefit could be mutually realized by a cooperative effort.

In October 1984 John Warren, electronics engineer for the Forest Service AESD unit, had completed preliminary proposals for a system named Fire-Mouse-Trap, which was intended for operation from a helicopter. Modification of the F-M-T for application in the fixed-wing and Loran-C guidance resulted in the TROLL system currently under development by Ron Hanks, Alaska Division of Forestry Senior Aviation Officer.

Hanks, working with the USDA Forest Service State and Private Forestry Office in Anchorage, submitted a development project proposal that was approved by the Alaska State Forester and the Forest Service Washington, DC, Aviation and Fire Management Office. The proposal aimed at accomplishing the designated goal by fire season of 1985 and speeding up development of the F-M-T project by 5 years.

The State used funding acquired through annual cooperative fire assistance to purchase the FLIR unit and computer support equipment. It also contracted for computer software designed to integrate Loran-C with the on-board Hewlett-Packard (HP) portable computer for data storage and transfer.

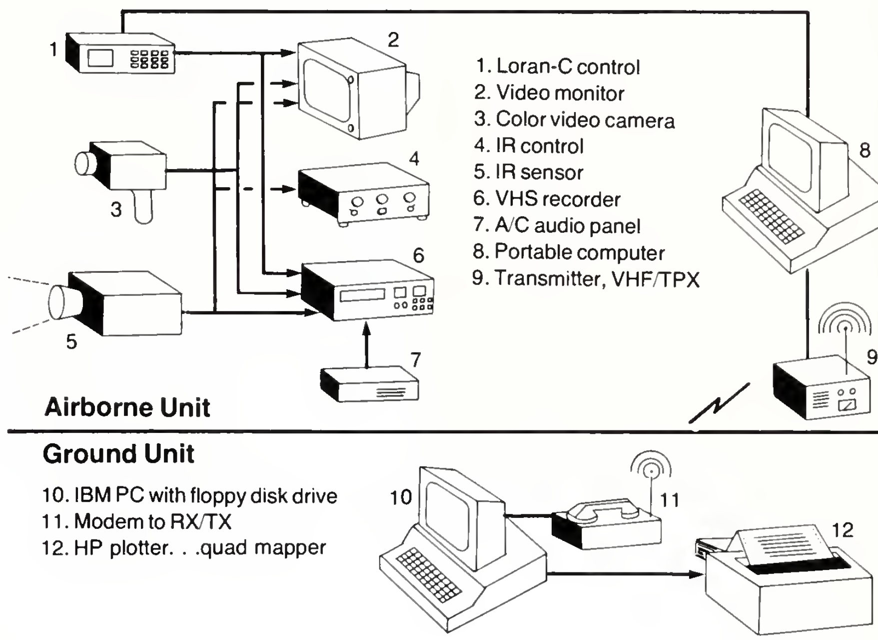

Figure 1—*Components of the ground and airborne units used in the TROLL system.*

Meanwhile the Forest Service was developing the software to drive the HP-computer and plotter units selected to perform the actual plotting. They also provided two HP-110 computers and a HP-7840 plotter for the State's use during the 1985 fire season.

By May 1985 the system was ready for experimental tests. John Warren and Dale Gable traveled to Anchorage to train the Alaska flight crew and to assist them with initial flight tests.

All airborne systems tested satisfactorily; TROLL was on its way toward operational deployment.

System Description

TROLL is a three-part system: airborne components, ground components, and air-to-ground transmission components, with the latter two being wholly dependent on input from the airborne system (fig. 1). Aerial components include a thermal sensing unit and color video camera that produce images on a common monitor and record the output on a standard ½-inch VHS videocassette recorder.

The airborne equipment was installed in the single-engine, low-wing, high-performance, two-person T-28 aircraft. The FLIR scanner head

sensor was mounted side by side with a color video camera beneath the aircraft in a specially designed compartment (fig. 2). The FLIR and video camera used a 45-degree (from vertical) viewing angle.

FLIR and color video cameras are used as aids to the pilot in determining the location of the fire perimeter. Color video and FLIR are also recorded and voice annotated for subsequent playback and review if necessary. The thermal IR view provided by the FLIR will often show the fire perimeter vividly when it cannot be detected visually or with color video.

The Loran-C is used to mark the aircraft's position in latitude and longitude. These loran position points are sent to the HP-110 for storage via the RS–232C interface. Accuracy of the system is dependent upon the loran system accuracy and the pilot's ability to stay over the fire perimeter in flight. The loran resolution (not accuracy) is in hundredths of a minute or 60 feet. Loran systematic errors can be calibrated out by flying over a known reference point and setting the loran or by simply using the reference to offset the plotter correlation on the ground.

The FLIR control unit, video monitor, Loran-C, video selector switches, power switches, and HP-110 personal portable computer are conveniently located for the back-seat operator (fig. 3). The pilot also has a Loran-C and a small video monitor. (Only one loran is necessary; it could be positioned for either pilot or operator use.)

Figure 2—*Under-fuselage modification of T–28 aircraft to permit mounting of IR sensors.*

The FLIR used is an Inframetrics model 445, which has 21° × 28° field of view and considerably better resolution than the model 525 previously tested and in use by the Forest Service. The HP-110 is a briefcase-size personal computer containing its own rechargeable battery pack. It is the processor-controller unit and provides storage for the latitude-longitude points sent from the loran via an RS–232C interface arrangement.

The ground equipment consists of the same HP–110 computer and an HP–7580B drafting plotter. Note that all equipment is commercially available, not specially designed. New software is required for interfacing the HP–110 with both the loran and the plotter.

Additional interfaces with IBM-PC hardware as well as several portable HP plotters have been achieved, which greatly enhances the adaptability of the system.

Air-to-ground transmission can be accomplished through a Wulfsberg-Flexcom system. Latitude and longitude data points stored in the HP–110 can be transmitted via voice-grade radio to ground-link with a State IBM-PC located in each area field office. These data can then be printed out, used to plot a fire perimeter map,

or transmitted via land line to another terminal point for processing.

The map is "scaled" by the computer using only two correlation points. The file name to be used is entered, and the plotter plots the fire perimeter(s) and spot fires to scale on the map. If the fire is on more than one map, as fires are apt to be, the other maps can be entered and their portions of the perimeter will also be plotted. The entire ground operation can probably be completed by an experienced operator in 10 minutes or so, depending on the length of the fire perimeter, number of spot fires logged, and the number of maps needed to show the fire.

VHS videotape acquired by the flight crew is returned with the aircraft and played on a VCR to visualize color, IR imagery, and audio either from the cockpit intercom or FM nets. Tapes could be air-dropped if necessary.

Conclusion

The TROLL system was given the opportunity to prove itself in several different environments this season. It was used during Alaska's normal fire season in May, June, and early July. It was then deployed to the Lower 48 where it was used in mapping, detection, and reconnaissance missions in Nevada, Idaho, Montana, and along the Canadian border. As of September 1 the aircraft had flown 164 hours, mapped 22 fires, been credited with detection of 17 new fires, and flown over 70 hours of reconnaissance and mop-up verification.

As with any new system several "bugs" were encountered, and modifications to the software will be accomplished during the winter months.

Among changes already made are purchases of a disk drive and a smaller portable plotter. This equipment will increase the minicomputer capability and decrease shipping problems encountered with the larger HP plotter. The new plotter can be transported in the aircraft rather than requiring individual shipping.

Thermal sensing systems are relatively rare in the civil environment for a variety of reasons, including costs, complexity, and recent technological developments only now reaching the marketplace. Large military and governmental agencies have encouraged technological development for use in their specialized applications, but until recently these developments were cost prohibitive for single-agency ownership.

Figure 3—*Rear cockpit of T-28 aircraft showing loran navigation equipment, video infrared display, and IR image recorder.*

This project proposes and defines a new phase in the evolution of fire mapping. It has far-reaching impact on the methods and equipment that have been in use for over 20 years in the fire services. It also realizes significant cost savings while achieving the desired accuracy, timeliness, practicality, and availability for field operations.

Thermal recorded observation and loran locating may not be the most enjoyable way to TROLL, but many Alaskans have already benefitted from this effort. ■

Equipment investment needed for TROLL system, broken down by components

Unit	Type	Cost
FLIR	Inframetrics model 445	
	Liquid nitrogen or	$37,000
	Compressed gas	44,000
Video	VCR color camera, belly mount, solid state	1,300
	VCR color camera, hand held	600
	5" Video monitor, solid state	800
	3" Video monitor, solid state	400
	VHS video tape recorder	500
	Video switching panel	100
Computer/ Plotter	(one of the following)	
	Hewlett-Packard HP–110 portable computer	2,600
	HP–7580—plotter, 8 pen color	8,500
	HP–7550—plotter, portable 8 pen	3,100
	HP–7475A—plotter, portable 6 pen	1,600
Disk drive	HP Disk drive	700
Loran-C	ARNAV–AVA 40, extended range capability, RS–232 Interface	6,000
Complete package as operated by Alaska DOF not including installation:		$61,700
Recommended cost for helicopter installation:		$49,300

Predicting Fire Behavior by Computer

The person who wants to control a wildfire or plan a fire to improve forest or rangeland conditions must understand how the fire is likely to behave. The type and amount of fuels, the weather, the fuel moisture, and the topography determine a forest fire's intensity and rate of spread, but the relationships among these variables are complex. That is why Forest Service Intermountain Forest and Range Experiment Station scientists have developed a computer program named BEHAVE for predicting fire behavior. BEHAVE incorporates the results of years of research on fire behavior into an easy-to-use and versatile system.

BEHAVE is designed to be what programmers call user-friendly. That is, it prompts the user for information about fuels, weather, and the fire situation. This feature minimizes the learning time and greatly aids users unfamiliar with computer terminology in language familiar to them.

Such programs eliminate the need for the researchers to simplify complex relationships for the fire manager. The equations expressing these relationships are solved almost instantly by the computer, giving the fire manager the best available predictions.

Training in the use of BEHAVE has been provided to fire managers throughout the Forest Service and to their counterparts in the Bureau of Land Management, the Bureau of Indian Affairs, the National Park Service, and the Fish and Wildlife Service, as well as several State organizations and universities. One of BEHAVE's first major applications was during a rash of large fires in Montana in August 1984. Money saved in suppression costs on one 23,000-acre fire near Helena more than paid the development costs. ■

Author Index 1985

Subject Index 1985

New Training and Publication Materials

The report on the fire entrapment incident on the Butte Fire, Salmon National Forest, indicates 60 lives were saved by fire shelters. Over 100 additional shelters were deployed during 1985. We further estimate two dozen additional lives have been saved by fire shelters since their use became mandatory on the fireline by some agencies in 1977.

Virtually everyone interviewed following entrapment situations believed hands-on shelter training is essential. Missoula Equipment Development Center's (MEDC) field trail publication "Your Fire Shelter" (August 1984) contains the most up-to-date information on fire shelter use and inspection. Key firefighting personnel should carefully review this publication. It includes such features as deploying your shelter, entrapment, inspection, and care and handling.

In addition, MEDC is in the process of updating the 16mm film on the use of the fire shelter, entitled "Your Way Out," to reflect important information gained through actual experiences. It should be available in the fall of 1986.

The life-saving success brought about by the use of shelters is unquestionable; however, steps need to be taken to ensure these successes do not develop into a complacency about fire safety or a reliance upon the fire shelter as something more than what it was intended for—a last resort. ■

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